INSTRUCTION MANUAL

TYPE __

MA-168A

Low Noise
AC Amplifier

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MP MASTER
MA34744

MILLIVAC
INSTRUMENTS

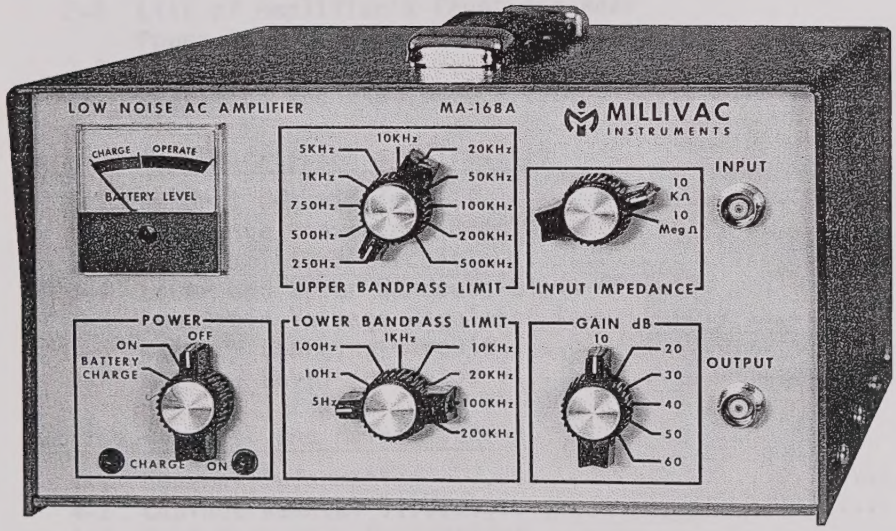
INSTRUCTION MANUAL

TYPE __

MA-168A

Low Noise AC Amplifier

SERIAL NO.



MILLIVAC
INSTRUMENTS, INC.
P.O. BOX 997 • SCHENECTADY, N.Y. 12301

PHONE 518-355-8300

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SPECIFICATIONS

GAIN	10dB to 60dB in 6 steps; 10dB, 20dB, 30dB, 40dB, 50dB and 60dB
FREQUENCY RESPONSE & ACCURACY	5Hz to 500KHz ±.2dB (3dB rolloff at low & high frequency limits)
LOWER BANDPASS LIMITS	5Hz to 200KHz in 8 steps; 5Hz, 10Hz, 100Hz, 1KHz, 10KHz, 20KHz, 100KHz and 200KHz
UPPER BANDPASS LIMITS	250Hz to 500KHz in 11 steps; 250Hz, 500Hz, 750Hz, 1KHz 5KHz, 10KHz, 20KHz, 50KHz, 100KHz, 200KHz and 500KHz
INPUT IMPEDANCE	MA-164A - 10KΩ MA-168A - 10KΩ and 10MegΩ, 20pF
INPUT MAXIMUM	1mV RMS (declining to .5mV at 500KHz)
NOISE	10KΩ INPUT IMPEDANCE position - less than 350nV RMS 10MegΩ INPUT IMPEDANCE position - less than 3μV RMS (noise figures referred to shorted input and at 100KHz bandwidth). For Noise Voltage as a function of Source Impedance see Fig. 1-3 (Page 6)
DISTORTION	Less than .25% - 10KΩ INPUT IMPEDANCE position Less than 1% - 10MegΩ INPUT IMPEDANCE position
OUTPUT IMPEDANCE	Approx. 100Ω
OUTPUT MAXIMUM	1V RMS
INPUT-OUTPUT CONNECTORS	BNC bayonnet type (2)
POWER SOURCE	(2) 6V rechargeable Ni-Cad batteries (internal), up to 24 hours continuous operation on an overnight charge
BATTERY LEVEL INDICATOR	Panel mount meter; color coded dial: OPERATE/RECHARGE
BATTERY CHARGING POWER	115V/230V AC, 45 - 1000Hz, less than 5W
CABINET DIMENSIONS	
PORTABLE	5.25" high X 8.25" wide X 14" deep (excluding kickstand)
RACKMOUNT	5.25" high X 19" wide X 11" deep
WEIGHT	Approx. 9 lbs.
ACCESSORIES-FURNISHED	2 ea. Test Leads, Millivac UG-201, detachable Millivac Part No. 900-3006 1 ea. 1000:1 Input Divider, detachable Millivac Part No. 900-3031 1 ea. AC Line Cord - 3 wire grounded, detachable Millivac Part No. 800-5122
ACCESSORIES-OPTIONAL	1 ea. 100:1 Input Divider Millivac Part No. 900-3030 1 ea. 10,000:1 Input Divider Millivac Part No. 900-3032

1-MA-164A-1001
1-MA-168A-1001

SECTION 1

GENERAL DESCRIPTION

1-1 FUNCTION OF THE AMPLIFIER

The function of the Amplifier is to convert very low signals (in the nanovolt and microvolt region) to levels that can be conveniently handled with ordinary (medium sensitivity) test and measuring equipment.

The inherent ultra low noise characteristic and the low distortion performance of the Amplifier allows achievement of the objective without distorting or contributing any additional noise to the signals to be observed or analyzed.

This makes the Amplifier ideally suited and useful for applications in basic research and such Technologies as Ultrasonics, Infra-Red, Sonar, Vibration Measurements and Nuclear Physics.

1-2 AMPLIFIER FEATURES - HIGHLIGHTS

A. All solid-state, battery operated

B. Portable, compact

C. Ease of operation, minimum amount of controls

D. High Input Impedance of 10MegΩ (on Model MA-168A only)

E. Rechargeable Ni-Cad batteries

F. BNC INPUT and OUTPUT connectors, Test Leads furnished

G. Easily serviced - open frame construction, printed circuit boards and plug-in solid-state devices

H. External Input Dividers

1-3 ELECTRICAL CHARACTERISTICS AND DESIGN FEATURES

The Millivac Models MA-164A and MA-168A LOW NOISE AC AMPLIFIERS are unique, highly sensitive, solid-state Test Instruments. These exceptional Amplifiers are capable of amplification of very low signal levels.

Their ultra-low internal noise, high sensitivity and distortion free characteristics allows amplification of levels in the nanovolt region. In the 10MegΩ INPUT IMPEDANCE position (MA-168A), amplification of levels in the microvolt region can be obtained.

Fig. 1-1 (Page 6) shows a 1μV-1KHz Signal and Fig. 1-2 (Page 6) shows a 3μV-1KHz Signal with the Amplifier BANDPASS LIMITS set to 10Hz LOWER and 10KHz UPPER BANDPASS LIMIT positions.

These signals are superimposed over the internal noise of the Amplifier and are easily detectable.

Full bandwidth of both Amplifiers ranges from 5Hz to 500KHz.

By means of selectable UPPER and LOWER BANDPASS LIMITS, narrower bandwidths are obtainable. This will result in reducing the Amplifier's internal noise and improving the signal to noise ratio.

Both upper and lower bandpass limiting filters are R/C networks exhibiting a 6dB/octave characteristic.

Table 1-1 (Page 6) lists Amplifier Noise Voltages as a function of different UPPER and LOWER BANDPASS LIMITS - for both the 10KΩ and 10MegΩ INPUT IMPEDANCE positions (with INPUT terminal shorted).

Noise levels, referred to INPUT terminal, are a function of source impedance. Fig. 1-3 (Page 6) shows Amplifier Noise Voltages as a function of Source Impedance over an approximate 100KHz bandwidth with the BANDPASS LIMITS set to 5Hz LOWER and 100KHz UPPER LIMIT positions.

The Amplifier GAIN is selectable from 10dB to 60dB in six (6) steps.

Ease of operation for all Amplifier functions is provided by a minimum of well marked controls.

An easy to read color-coded meter indicates the internal Ni-Cad batteries' operational condition.

The ultra low noise characteristic of these Amplifiers has been achieved through the selection of special purpose low noise transistors and components. Long term stability and optimum performance are assured with the use of two (2) feedback loops. An effective DC self biasing loop compensates for drifts and the AC feedback loop assures gain stability.

A low drain electronic voltage regulator supplies power to the various Amplifier circuits.

Power source of the Amplifier consists of two (2) internal Ni-Cad rechargeable batteries. A built-in battery charger operates from 115V/230V AC power line.

To extend the Amplifier's dynamic range, an external 1000:1 Input Divider is provided. Additional Dividers (10,000:1 and 100:1) are available as options. The Dividers consist of low noise precision resistors assembled in a well shielded housing.

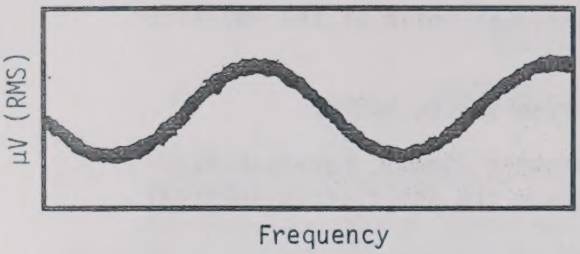


Fig.1-1 1µV-1KHz Signal-10KHz Bandwidth (10Hz & 10KHz Bandpass Limits) MA-164A & MA-168A in the 10KΩ Input Impedance Position

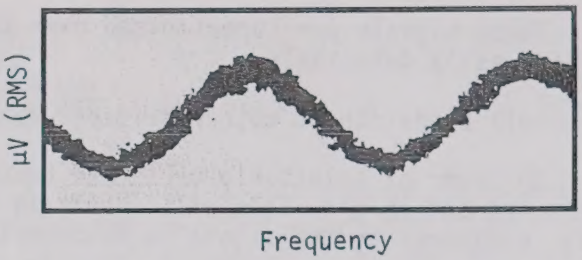


Fig.1-2 3µV-1KHz Signal-10KHz Bandwidth (10Hz & 10KHz Bandpass Limits) MA-168A in the 10MegΩ Input Impedance Position

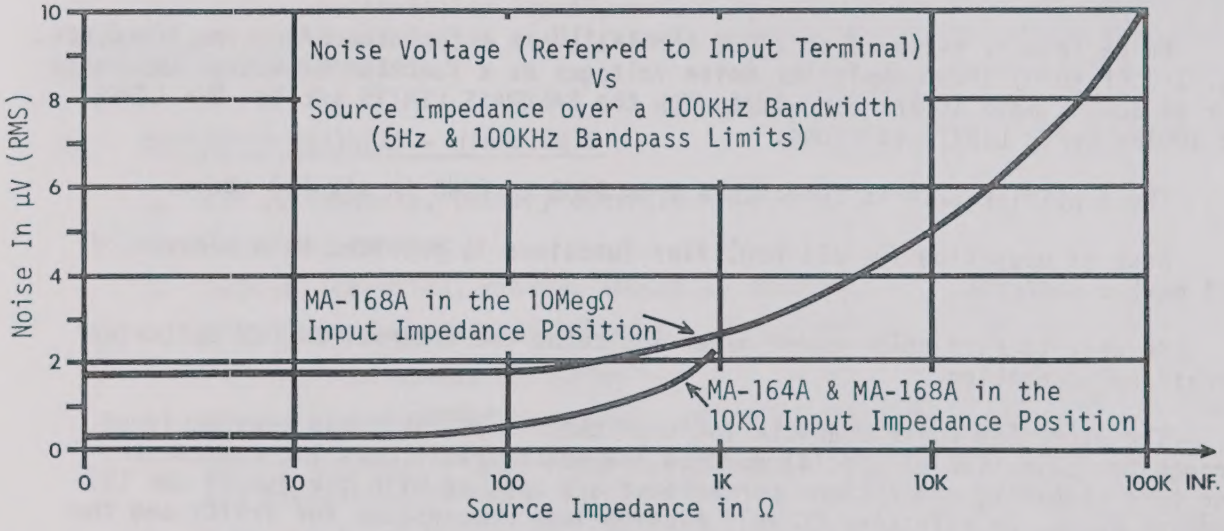


Fig.1-3 Noise Voltage Vs Source Impedance

Bandpass Limits		Noise Voltage	
Lower Limit Frequency (in Hz)	Upper Limit Frequency (in KHz)	MA-164A & MA-168A in the 10KΩ Input Impedance Position (in nV)	MA-168A in the 10MegΩ Input Impedance Position (in µV)
5	500	500	3.65
5	200	330	2.45
5	100	250	1.90
5	50	175	1.45
5	20	120	1.10
5	10	85	1.00
5	5	65	0.95
10	10	85	0.95
100	10	80	0.80
1000	10	75	0.65

Table 1-1 Noise Voltage (Referred to Shorted Input)

1-MA-164A-1001
1-MA-168A-1001

SECTION 2

OPERATING INSTRUCTIONS

2-1 INITIAL INSPECTION

The Amplifier should be inspected for damages which may have occurred during shipment. This should be done prior to operating the unit. Should any damages be revealed, refer to the Guarantee Page under "Claim for Damages in Shipment".

2-2 ACCESSORIES FURNISHED

A. Two (2) detachable Test Leads (Millivac UG-201, Part No. 900-3006) are supplied with the Amplifier. They are used for INPUT and OUTPUT connections and are interchangeable. Each Lead utilizes a 4' shielded cable with solid copper color-coded alligator clips.

B. 1000:1 Millivac Input Divider (Part No. 900-3031). Divider accuracy ±2%.

C. AC Line Cord, detachable, 3 wire grounded cable (Part No. 800-5122), for charging the internal Ni-Cad batteries.

2-3 ADDITIONAL ACCESSORIES AVAILABLE

For input level attenuations of 100:1 and 10,000:1 the following optional external Millivac Input Dividers are available:

100:1 Input Divider Millivac Part No. 900-3030. Divider accuracy ±2%.

10,000:1 Input Divider Millivac Part No. 900-3032. Divider accuracy ±2%.

2-4 POWER REQUIREMENTS

A. Internal Batteries: The Amplifier circuitry is powered by two (2) 6V internal rechargeable Ni-Cad batteries. When brought up to full capacity following an overnight charge, they will deliver 24 hours of continuous operation.

CAUTION: The Amplifier should not be operated when the BATTERY LEVEL has fallen below the OPERATE range. Rated specifications and performance will deteriorate.

B. Battery Charging: To charge the internal Ni-Cad batteries, connect the AC Line Cord, as furnished, into its polarized POWER connector on the power panel. Ascertain that the LINE VOLTAGE selector switch is set to agree with the line voltage to be used. Connect the Cord's plug to the line voltage source. Rotate the POWER selector switch to BATTERY CHARGE. Note that the CHARGE pilot light is illuminated. An overnight charging will restore the batteries to 100% capacity and provide up to 24 hours of continuous operation.

2-5 LIST OF AMPLIFIER'S FRONT AND REAR POWER PANEL COMPONENTS AND CONTROLS

A. Front Panel. See Fig. 2-1 (Page 9)

1. POWER Selector Switch: A three (3) position switch selects the following functions: OFF, ON and BATTERY CHARGE.
   In the ON position the internal batteries energize the Amplifier circuits and the AC power line (hot and neutral) is disconnected from the unit.
   In the BATTERY CHARGE position, the AC power line is connected to the battery charging power supply and the internal batteries are disconnected from the Amplifier circuits.
2. BATTERY LEVEL: A panel mounted meter is used to indicate the operating condition of the internal batteries in both the ON and BATTERY CHARGE positions. (also see Section 2-4).
3. Meter Mechanical Zero: Provides the means to mechanically zero the meter pointer and is performed with the Amplifier de-energized.
4. ON Pilot Light: Indicates battery power is being used and will be illuminated in the ON position only.
5. CHARGE Pilot Light: Indicates AC line power is being applied to the battery charging circuit.
6. INPUT Connector: Accepts either one of the Test Leads furnished or one (1) of the external Millivac Input Dividers.
7. OUTPUT Connector: Accepts either one (1) of the Test Leads furnished.
8. INPUT IMPEDANCE Switch: (Model MA-168A only) selects the 10KΩ or 10MegΩ INPUT IMPEDANCE position.
9. GAIN Switch: Amplifier gain can be selected in 6 steps; 10dB to 60dB.
10. UPPER BANDPASS LIMIT Switch: 250Hz to 500KHz in 11 steps; 250Hz, 500Hz, 750Hz, 1KHz, 5KHz, 10KHz, 20KHz, 50KHz, 100KHz, 200KHz and 500KHz.
11. LOWER BANDPASS LIMIT Switch: 5Hz to 200KHz in 8 steps; 5Hz, 10Hz, 100Hz, 1KHz, 10KHz, 20KHz, 100KHz and 200KHz.

B. Rear Power Panel. See Fig. 2-2 (Page 9)

1. POWER Connector: Accepts the 3 wire grounded polarized AC Line Cord, as furnished. Voltage and frequency requirements are marked on the rear power panel. AC line power is used for charging the internal Ni-Cad batteries only. The AC power line is automatically disconnected from the battery charging circuit when operated in the ON position.
2. FUSE Holder: Contains a 0.3 amp "slo-blo" fuse. Always replace with the same type and manufacture as factory installed.
3. LINE VOLTAGE Selector: Slide switch for either 115V or 230V AC line operation and must be set to agree with the line voltage to be used.

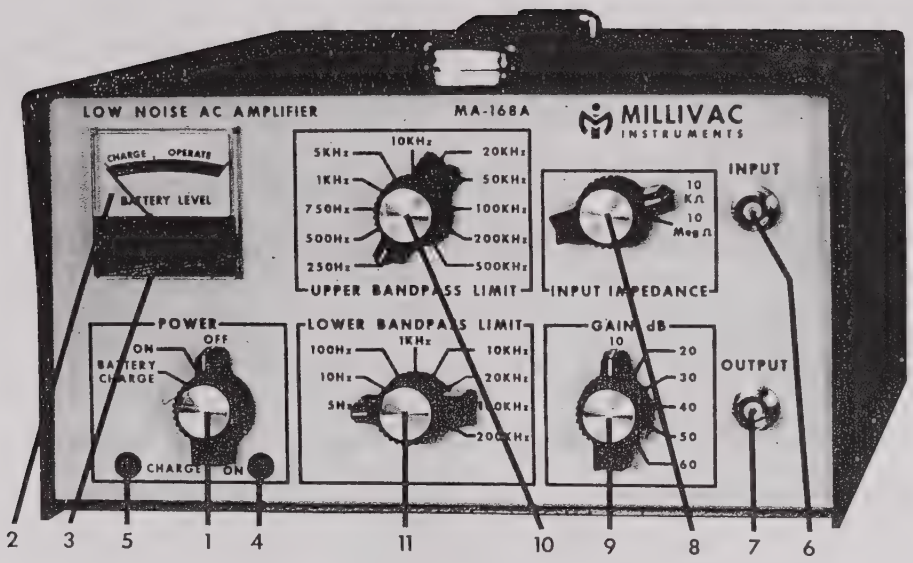


Fig. 2-1 Front Panel Components and Controls

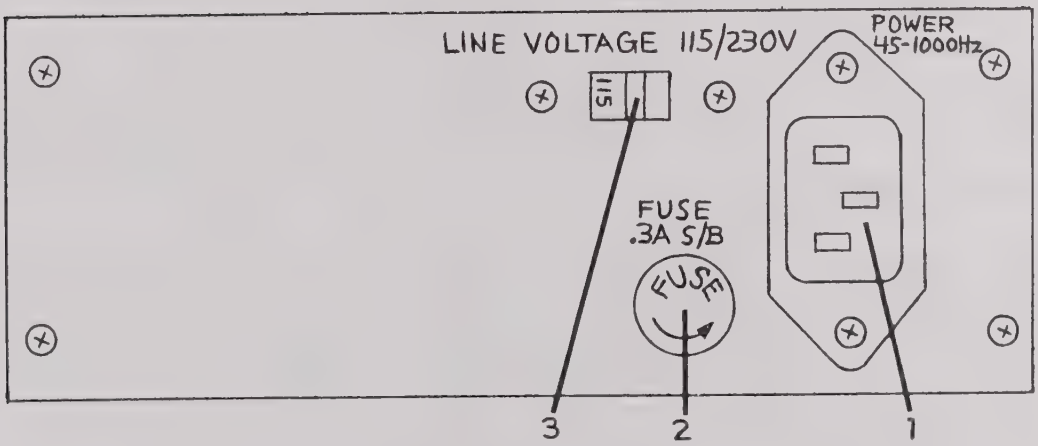


Fig. 2-2 Rear Power Panel Components and Controls

1-MA-164A-1001
1-MA-168A-1001

2-6 GENERAL PRECAUTIONS

Due to its extreme sensitivity and low noise characteristics, the Amplifier is susceptible to signal interference from a number of sources such as power lines, electric and magnetic fields, ground currents and communication signals.

To minimize the effects of these signals, the following general operating precautions should be observed:

A. Location: Operating the Amplifier in the immediate vicinity of line powered or signal emitting test equipment may cause undesirable pick-ups. Magnetic field emission from the equipment's power transformer could also effect the Amplifier's performance. To minimize these effects, relocate the Amplifier to an area away from the test equipment. Also rotate the Amplifier to a position where these pick-ups become minimal.

B. Power Line Emissions: Operating the Amplifier near active AC power lines, even those several feet away, may cause hum pick-ups. Relocate and reposition the Amplifier to where hum pick-ups become minimal.

C. Grounds: Poorly grounded connections between the Amplifier and other attached equipment may cause large signal interference. It is important for all ground connections to be fault free.

D. Output Monitoring Equipment: The output monitoring equipment (such as oscilloscope or voltmeter)may feed a hum signal back into the Amplifier. The monitor could have excessive power transformer emissions which would produce large hum currents in the common ground system. In some cases, it may become necessary to use battery operated equipment or to disconnect the monitor once the signal level has been measured.

E. Input Signal Source: The input signal source, if AC line powered, may feed a hum signal into the Amplifier. Caution should be used where signal source attenuators, decade boxes, microvoltmeters and other devices are attached to the Amplifier's Input. They may produce line hum pick-ups especially when not electrically shielded.

F. AC Line Cord: It is advisable to physically remove the AC line cord, supplied with the Amplifier, from its connector to avoid any pick-ups.

NOTE: Using the Amplifier where strong RFI signals are present may require operating the Amplifier in a completely enclosed electrostatically shielded box or room.

2-7 OPERATION AND USE

To assure that the Amplifier's rated specifications and performance are maintained, the following procedure should be observed:

A. BATTERY LEVEL: Rotate the POWER switch to ON and observe the BATTERY LEVEL meter. It should read in the OPERATE range. The internal Ni-Cad batteries are fully charged prior to shipment from the factory. Should the meter read in the CHARGE range or just at the red CHARGE line (between the CHARGE and OPERATE ranges), the batteries should be re-charged. Refer to Section 2-4B, Battery Charging, for instructions.

B. Preliminary Test: Verify that all General Precautions, as outlined in Section 2-6, have been observed.

Set the Amplifier's controls to the following positions: GAIN dB to 60, UPPER BANDPASS LIMIT to 100KHz, LOWER BANDPASS LIMIT to 5Hz and for the Model MA-168A, INPUT IMPEDANCE to 10KΩ.

1. Gain Test: Attach the 1000:1 Input Divider, as supplied, to the Amplifier's INPUT connector. Apply a signal of 1V RMS at 1KHz. Rotate the POWER switch to ON. With an AC voltmeter and an oscilloscope connected to the OUTPUT connector (using the Test Lead supplied) measure 1V, ±.2dB. Observe the waveshape on the oscilloscope.

   CAUTION: Do not apply more than 1mV directly to the INPUT connector. For signals larger than 1mV, use the 1000:1 Input Divider supplied or one of the optional Millivac Dividers.

2. Input Noise Test: Disconnect the signal source and 1000:1 Input Divider. Short the INPUT connector. A BNC shorting cap is preferable for this purpose. The noise measured at the OUTPUT terminal should read less than 350nV on the MA-164A and in the 10KΩ position of the MA-168A. In the 10MegΩ position of the MA-168A, the noise should read less than 3μV. The output monitor should be true RMS responding. Should an average responding monitor be used instead of a true RMS monitor, multiply the reading by 1.13.

   In addition, the Amplifier's 100KHz upper-bandpass filter has a single R/C roll off. The actual bandwidth is: $(\pi/2) \times 100KHz = 157KHz$.

   Since the RMS noise is related to the square root of the noise bandwidth, the equation: $(E\ noise)/(\sqrt{\pi/2}) = E\ out$ corrects for the difference.

The Gain and Input Noise Tests will verify the proper operating condition of the Amplifier. Once established, the Amplifier is ready for use.

C. Operation: For input levels of 1mV or less, apply the signal directly to the INPUT connector, using one of the Test Leads supplied. For input signal levels over 1mV, use the 1000:1 Input Divider, as supplied, or one of the optional Millivac Input Dividers.

   NOTE: Using the Amplifier without the Input Divider greatly increases the sensitivity towards hum pick-ups. All General Precautions as outlined in Section 2-6 must be observed.

The Amplifier's Noise Voltage will increase as the signal source's output impedance increases. Fig. 1-3 (Page 6) shows the relationship between Noise Voltage, as referred to the INPUT terminal and various source impedances.

Set the UPPER and LOWER BANDPASS LIMIT switches to match the bandwidth of the input signal frequency. This allows for optimum signal to noise ratio.

Set the GAIN dB switch for the appropriate level of amplification.

SECTION 3

DESCRIPTION OF CIRCUITRY

3-1 GENERAL DESCRIPTION

Models MA-164A and MA-168A (in the 10KΩ INPUT IMPEDANCE position) have the INPUT directly coupled to the main amplifier circuit.

Model MA-168A (in the 10MegΩ INPUT IMPEDANCE position) the INPUT is first coupled to the impedance converter which achieves its high impedance characteristic.

The main amplifier is a high-gain direct-coupled two (2) stage amplifier with both AC and DC feedbacks. AC feedback produces overall stability while DC feedback counters DC bias drifts. A master gain control adjusts the gain of the main amplifier circuit.

A ladder type low impedance attenuator provides selection of gain from 10dB to 60dB.

The attenuator output is signal conditioned by an eight (8) step lower bandpass limit circuit for lower frequencies. This is proceeded by an emitter follower stage which isolates the lower bandpass limit circuit from the upper bandpass limit circuit.

The eleven (11) step upper bandpass limit circuit provides selectability of the Amplifier's upper frequencies. This is proceeded by an emitter follower stage which isolates the bandpass limit circuit from the output. Also, the emitter follower stage serves to provide a relatively low output impedance.

The power supply is a low-drain electronic voltage regulator circuit. Power source for the Amplifier is obtained from two (2) internal rechargeable Ni-Cad batteries.

For the following detailed description of each circuit, the Block Diagram, Fig. 3-1 (Page 15) as well as the Schematic Diagram (attached at the end of this Instruction Manual) should be used as a reference source.

3-2 IMPEDANCE CONVERTER (Model MA-168A only)

The converter's high impedance input at 3Q1 (FET) is in the order of 100MegΩ. Overload protection is provided by four (4) diodes; 3D1, 3D2, 3VR1 and 3VR2. Transistor 3Q2 is used as a current sink to stabilize the bias current of the FET. Overall gain of the impedance converter is in the order of 0.91.

Low output impedance, as displayed at capacitor 3C6, is approximately 12Ω.

3-3 MAIN AMPLIFIER CIRCUIT

The main amplifier circuit consists of the following stages; 1st amplifier, 3Q3; follower, 3Q4; current sink, 3Q5; 2nd amplifier, 3Q6; and output follower, 3Q7. These stages are direct-coupled and have high overall gain. Local DC supply voltage de-coupling is used at each stage's collector to minimize possible oscillations between stages.

Two (2) feedback loops are used around the main amplifier for overall stability. The DC feedback loop, from the collector of 2nd amplifier stage, 3Q6, to the base of 1st amplifier stage, 3Q3, provides gain stability. The AC feedback loop, from the emitter of follower stage, 3Q7, to the emitter of 1st amplifier stage, 3Q3, compensates for bias drifting. The master gain adjust control, variable resistor, 3R29, is located in the AC feedback loop and is used to adjust the gain of the main amplifier circuit. Further information on amplifier gain and testing can be found in Section 4-4 (Page 18), Gain Test and Adjustment Procedure.

A ladder type low impedance attenuator follows the main amplifier circuit. The attenuator consists of GAIN dB switch 1S2 with its associated circuitry. The attenuator output maintains a constant impedance in 10dB steps. This provides the Amplifier with a gain selection from 10dB to 60dB.

3-4 LOWER AND UPPER BANDPASS LIMIT CIRCUITS

The bandpass circuits consist of single R/C roll-off type networks exhibiting a 6dB/octave characteristic. Each network corresponds to a position on either the LOWER or UPPER BANDPASS LIMIT switches.

An emitter follower stage proceeds each bandpass circuit which provides isolation and low impedance output. Local DC supply voltage de-coupling is used at each stage's collector to minimize possible oscillations between stages.

Use of the LOWER and UPPER BANDPASS LIMIT switches will facilitate in narrowing of the Amplifier's bandwidth therefore improving the overall signal to noise ratio.

3-5 LOW-DRAIN VOLTAGE REGULATOR POWER SUPPLY

The Amplifier circuitry is driven from the +12.00V regulator power supply whose power source are two (2) internal rechargeable Ni-Cad batteries. AC line power is not used as a source for the power supply. Should the Amplifier be connected to the AC line while being used in the ON position, the AC line (hot and neutral) will be automatically disconnected. This will electrically "float" the Amplifier to free it from spurious and harmful AC line interference.

The low-drain feature aids in lengthening the operating life of the batteries. This is accomplished by maintaining an approximate 80mV drop across the power supply (from input to output).

The power supply consists of a complimentary pair of transistors, 2Q1 and 2Q2, to handle the load currents. Operational amplifier, 2IC1, serves as a constant current source. Pins 1 and 8 of 2IC1 are used as a control element while the voltage from zener diode, 2VR1, is the reference source. The +12.00V adjust control, variable resistor 2R8, adjusts the power supply output to exactly +12.00V.

All resistors (except decoupling resistor, 2R3) are low noise, precision type. The design of the power supply provides a low impedance output. The supply delivers a low noise, regulated +12.00V to various Amplifier circuits.

3-6 BATTERY CHARGING CIRCUIT

The battery charging circuitry consists of a dual primary input, step down power transformer, 2T1; bridge rectifier, 2D1 and 2D2; filter capacitor, 2C1; series diode, 2D3 and series resistor, 2R2. Input AC line power (hot and neutral) is connected to the charging circuit only when in the BATTERY CHARGE position. In addition, the internal Ni-Cad batteries will be automatically disconnected from the regulator power supply.

The LINE VOLTAGE selector switch, 4S1 (rear power panel), is used to make battery charging operational from either 120V or 230V AC line. Ascertain the switch is set to agree with the line voltage source to be used prior to energizing.

3-7 BATTERY LEVEL INDICATOR

The BATTERY LEVEL indicator consists of a dual color dial, panel mount meter which shows the internal rechargeable Ni-Cad batteries operating condition. The green bar area indicates a capacity of sufficient voltage to operate the Amplifier at its rated specifications. The red bar area indicates the batteries need to be charged. Attempting to operate the Amplifier while the level has fallen into the red area will result in deterioration of rated specifications, performance and a considerable increase in noise level voltage. For battery charging information, refer to Section 2-4B (Page 7).

CAUTION: Do not allow the batteries to discharge below the operate range.

The BATTERY LEVEL indicator, 1M1, is battery driven thru a resistive network consisting of 2R11 and 2R12 and a zener diode, 2VR2. Variable resistor, 2R12, allows correction for differences in meter coil sensitivities. Zener diode, 2VR2, converts the meter scale into an expanded one. Constant battery level monitoring is provided when using the Amplifier in the ON or BATTERY CHARGE mode.

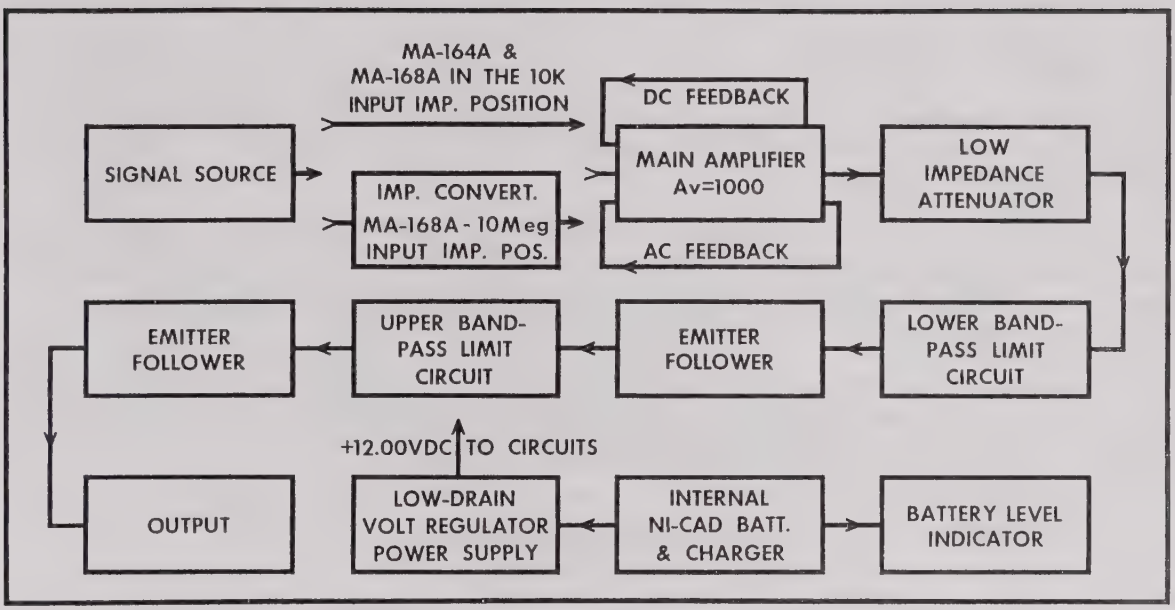


Fig. 3-1 Block Diagram

SECTION 4

TEST AND MAINTENANCE

4-1 GENERAL INFORMATION

The procedures described below should be used to evaluate the Amplifier's overall performance. They will also be helpful in the task of maintaining or trouble-shooting the Amplifier.

To aid in servicing the Amplifier, major components and test points are labeled on the printed circuit boards for reference purposes. All circuit boards and components are readily accessible; all shield plates are easily removable. Also, all transistors and integrated circuits are installed in plug-in sockets.

Should it become necessary for component replacement, it is recommended the component be replaced with one of the same type and manufacture as originally installed. This will ensure the Amplifier's original operating characteristics and performance will be maintained.

A detailed Parts List can be found in Section 5 of this Manual.

4-2 CABINET REMOVAL

Should it become necessary to remove the cabinet, the following procedure should be used:

CAUTION: Disconnect the Amplifier from the AC power line and set the POWER switch to OFF before removing the cabinet.

Remove the eight (8)Phillips pan head screws from the cabinet's lower sides (4 per side) and lift the cabinet straight up to clear the Amplifier. To remove the chassis's bottom cover plate, remove the six (6) Phillips pan head screws from the side edges (3 per side) and lift the plate off.

The main amplifier board is shielded on both sides by two (2) metal plates. To gain access to the board, remove the plates' screws as shown in Fig. 4-1(Page 17).

When operating the Amplifier out of its cabinet, adequate external shielding will be required. In addition, all internal shield plates should be in place and securely fastened to the chassis. Remove these plates only for component replacement or voltage measurements.

External shielding is required to prevent stray AC/RF fields from penetrating into the extremely sensitive input circuit. For proper shielding, place aluminum plates of sufficient size to cover the top, bottom and two (2) sides; ground all plates to chassis.

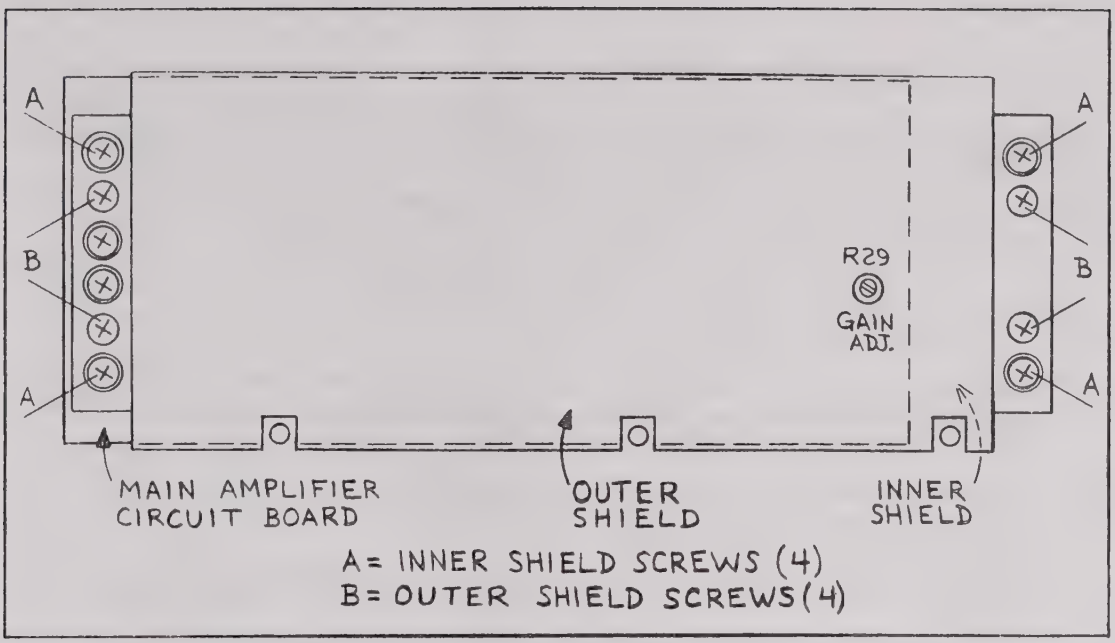


Fig. 4-1 Main Amplifier Board Inner and Outer Shield's Mounting Screws Location

4-3 TEST EQUIPMENT RECOMMENDED

A. Signal Source: Output range of 1mV F.S. to 3V F.S. RMS. Frequency range of 5Hz to 500KHz with less than 1% distortion. Recommended are Hewlett-Packard Models 739AR and 200S or equivalents.

B. Input Monitor: AC Voltmeter with a range of 1mV F.S. to 3V F.S. RMS, accuracy of ±2% of F.S. or better at 5Hz to 500KHz. Recommended is Millivac Model PM-512A or equivalent.

C. 1000:1 Divider: Millivac Part No. 900-3031 - supplied with Amplifier.

D. Output Monitor: AC Voltmeter with a range of 1mV F.S. to 3V F.S. RMS, accuracy of ±2% of F.S. or better at 5Hz to 500KHz. Recommended is Millivac Model PM-512A or equivalent.

E. Oscilloscope: Vertical sensitivity of 1mV/cm. Recommended is Tektronix Model 503 or equivalent.

F. Multimeter: DC: range of 3mV F.S. to 30V F.S.; AC: range of 3mV F.S. to 300V F.S.: Ohms: 1Ω to 100MegΩ. Recommended is Millivac Model MV-973A or equivalent.

G. Digital Voltmeter: 3½ digits DC, range of 1mV F.S. to 1000V F.S. Recommended is Millivac Model PM-403B or equivalent.

H. Auxilary DC Power Supply: Variable output from +7V to +15V, 50mA minimum. Recommended is Hewlett-Packard Model 6216B or equivalent.

4-4 GAIN TEST AND ADJUSTMENT PROCEDURE

This test will verify the overall gain accuracy of the Amplifier as well as the accuracy of the additional five (5) positions/settings of the GAIN dB switch.

Verify that all General Precautions as outlined in Section 2-6 and Operation and Use Procedures as outlined in Section 2-7 have been observed.

A typical test equipment set-up for gain adjustment is shown in Fig. 4-2 (Page 18).

A. Set the Amplifier's controls to the following positions: GAIN dB to 60, UPPER BANDPASS LIMIT to 100KHz, LOWER BANDPASS LIMIT to 5Hz, and for the Model MA-168A, INPUT IMPEDANCE to 10KΩ.

B. Attach the 1000:1 Input Divider, as supplied, to the Amplifier's INPUT connector. Apply a signal of 0 dB (1V range of the input monitor) at 1KHz. Rotate the POWER switch to ON.

C. Measure 0 dB, ±0.2dB (1V range of the output monitor) at the Amplifier's OUTPUT.
Should this test show the tolerance to be in excess of ±0.2dB, the main amplifier gain can be re-adjusted. To adjust, it will be necessary to remove the Amplifier's cabinet. Refer to Section 4-2 (Page 16) Cabinet Removal for instructions.

D. With the GAIN dB switch set to 60, apply a signal of 0 dB at 1KHz. Locate gain adjust control, 3R29, in the middle rear of the main amplifier board. Access for adjustment of the control is reached thru a clearance hole in the outer shield plate. Rotate the gain adjust control until a reading of 0 dB, ±0.2dB occurs on the output monitor. Re-attach the Amplifier's cabinet.

E. Simultaneously rotate the GAIN dB switch and the output monitor's range switch downward in 10dB steps. Measure the output dB's for each step and note the difference in gain figures. Tolerance for each step is ±0.2dB. Should this test show the tolerance to be in excess of ±0.2dB for any given step, measure the low impedance attenuator resistors against their rated values and tolerances. Replace any faulty component found.

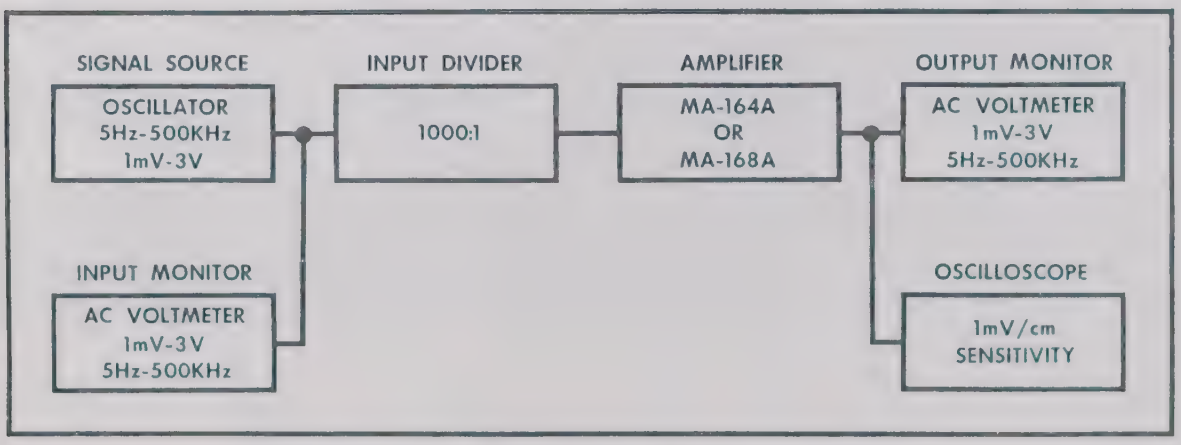


Fig. 4-2 Typical Test Equipment Set-up for Main Amplifier Gain Adjustment

1-MA-164A-1001
1-MA-168A-1001

4-5 INOPERATIVE AMPLIFIER

A. Check for low battery level by rotating the POWER switch to ON and observe the BATTERY LEVEL indicator. If the indicator shows the level to be in the red bar range area, battery charging is necessary. Refer to Section 4-12 (Page 24) for battery charging information.

B. Check the POWER switch to make sure it is in the ON position.

C. Check the ON pilot light. If the pilot light is on but the Amplifier fails to respond, verify the input signal source and output monitor for its operating condition.

D. Check the Input and Output Test Leads and the external Input Resistive Divider for possible damage.

E. Try other GAIN and BANDPASS positions to determine if those being used are inoperative.

Any further trouble-shooting will require removal of the Amplifier's cabinet. Refer to Section 4-2 (Page 16) for details.

G. Rotate POWER switch to ON. Check the power supply for voltages and compare to those as shown on the Schematic Diagram.

H. Check the amplifier and filter board assemblies for DC supply voltages and compare to those as shown on the Schematic Diagram.

4-6 ERRATIC OR INTERMITTENT BEHAVIORS

A. Check for low battery level by rotating the POWER switch to ON and observe the BATTERY LEVEL indicator, If the indicator shows the level to be in the red bar range area, battery charging is necessary. Refer to Section 4-12 (Page 24) for battery charging information.

B. Check the input signal source, Input and Output Test Leads, external Input Resistive Divider and output monitor for possible cause.

C. Try other GAIN and BANDPASS positions to determine if those being used are inoperative.

Any further trouble-shooting will require removal of the Amplifier's cabinet. Refer to Section 4-2 (Page 16) for details.

D. With the cabinet, bottom cover plate and two (2) shield plates removed, visually inspect for damaged circuit boards, broken wires or loose mechanical parts.

E. Rotate POWER switch to ON. Check the power supply for voltages and compare to those as shown on the Schematic Diagram.

F. Check the amplifier and filter board assemblies for DC supply voltages and compare to those as shown on the Schematic Diagram.

Should the problem persist, refer to the following trouble-shooting procedure for individual circuits.

4-7 IMPEDANCE CONVERTER (MA-168A only)

Trouble-shooting the impedance converter's direct-coupled stages consists of comparing the DC voltages of FET, 3Q1, and transistor, 3Q2, to those as shown in Table 4-1 (Page 20). A discrepancy in voltage measurements will indicate the faulty stage. Remove the faulty stage's solid-state device from its socket and by using a transistor/FET tester, check the device's condition. Or, verify the device's condition by substitution with a known good one. Replace any faulty device found.

Should the faulty stage's condition remain, measure the values of all resistors and capacitors involved against their rated values and tolerances. This procedure should locate the faulty component. Replace any faulty component found.

Prior to measuring, set the Amplifier's GAIN dB switch to the 60dB position. Also short the INPUT connector's signal carrying terminal to the connector's ground. Use the multimeter to make the following DC voltage measurements:

TABLE 4-1 IMPEDANCE CONVERTER DC VOLTAGES

Device Pin	Impedance Converter Device	
	3Q1	3Q2
Source (S)	+6.98V	—
Gate (G)	**	—
Drain (D)	+4.62V	—
Emitter (E)	—	+3.98V
Base (B)	—	+4.62V
Collector (C)	—	+11.85V

Pin Layouts for FET, 3Q1, and Transistor, 3Q2

3Q1

3Q2

Bottom Views

** cannot be measured

All voltages shown are nominal values, ±10%

4-8 MAIN AMPLIFIER CIRCUIT

Trouble-shooting the main amplifier's DC coupled stages consists of comparing each of the individual transistor's emitter-base-collector voltages to those as shown in Table 4-2 (Page 21). A discrepancy in voltage measurements will indicate the faulty stage. Remove the faulty stage's transistor from its socket and by using a transistor tester, check the transistor's condition. Or, verify the transistor's condition by substitution with a known good one. Replace any faulty transistors found.

Should the faulty stage's condition remain, measure the values of all resistors and capacitors involved against their rated values and tolerances. This procedure should locate the faulty component. Replace any faulty component found.

Prior to measuring, set the Amplifier's GAIN dB switch to the 60dB position. Also short the INPUT connector's signal carrying terminal to the connector's ground. Use the multimeter to make the following DC voltage measurements:

Table 4-2 MAIN AMPLIFIER CIRCUIT DC VOLTAGES

Transistor Pin	Main Amplifier Circuit Transistor				
	3Q3	3Q4	3Q5	3Q6	3Q7
Emitter (E)	+0.023V	+3.41V	+2.76V	+0.83V	+6.57V
Base (B)	+0.787V	+4.02V	+3.41V	+1.48V	+7.21V
Collector (C)	+4.02V	+11.97V	+7.21V	+2.76V	+11.76V

All voltages shown are nominal values, ±10%

Pin Layout for Transistors 3Q3 to 3Q7

Bottom View

To test and adjust the main amplifier's gain, refer to Section 4-4 (Page 18) of this Manual.

4-9 UPPER AND LOWER BANDPASS LIMIT CIRCUITS

Trouble-shooting the upper and lower bandpass limit circuits consists of comparing each of the circuit's transistor's emitter-base-collector voltage to those as shown in Table 4-3(Page 22). Discrepancy in voltage measurements will indicate the faulty circuit. Remove the faulty circuit's transistor from its socket. By using a transistor tester, check the transistor's condition. Or, verify the transistor's condition by substitution with a known good one. Replace any faulty transistor found.

Should the faulty circuit's condition remain, measure the values of all resistors and capacitors involved against their rated values and tolerances. This procedure should locate the faulty component. Replace any faulty component found.

Prior to measuring, set the Amplifier's GAIN dB switch to the 60dB position. Also short the INPUT connector's signal carrying terminal to the connector's ground. Use the multimeter to make the following DC voltage measurements:

TABLE 4-3 UPPER AND LOWER BANDPASS LIMIT CIRCUITS DC VOLTAGES

Device Pin	Bandpass Limit Circuits Transistor	
	5Q1	5Q2
Emitter (E)	+4.90V	+2.93V
Base (B)	+5.45V	+3.52V
Collector (C)	+11.90V	+11.87V

Pin Layout for Transistors 5Q1 and 5Q2

Bottom View

All voltages shown are nominal values, ±10%

4-10 POWER SUPPLY

A. Check for low battery level by rotating the POWER switch to ON and observe the BATTERY LEVEL indicator. If the indicator shows the level to be in the red bar range area, battery charging is necessary. Refer to Section 4-12 (Page 24) for battery charging information.

B. Rotate the POWER switch to ON. With the DC digital voltmeter attached to 2TP1, rotate variable control, 2R8 (power supply board) until a reading of +12.00V is obtained.

C. If +12.00V cannot be obtained,trouble-shoot the power supply by comparing the emitter-base-collector voltages of transistor, 2Q1 and 2Q2 and the pin voltages of operational amplifier, 2IC1, to those as shown in Table 4-4. A discrepancy in the voltage measurement's will indicate the faulty stage. Remove the faulty stage's transistor from its socket by using a transistor tester, check the transistor's condition. Or, verify the transistor's condition by substitution with a known good one. If a faulty operational amplifier is suspected, verify its condition by substitution with a known good one. Replace any faulty device found.

D. When the faulty condition has been corrected, repeat Step 4-10B to adjust the power supply's output to +12.00V.

TABLE 4-4 POWER SUPPLY DC VOLTAGES

Device Pin	Power Supply Device		
	2Q1	2Q2	2IC1
Emitter (E)	+13.00V	+4.30V	—
Base (B)	+12.30V	+4.86V	—
Collector (C)	+12.00V	+12.30V	—
1	—	—	+4.86V
2	—	—	+3.60V
3	—	—	+3.60V
4,5,6	—	—	0V
7	—	—	N/A
8	—	—	+12.00V

Pin Layout for Transistors 2Q1 and 2Q2 Operational Amplifier 2IC1

2Q1 & 2Q2

2IC1

Bottom Views

All voltages shown are nominal values, ±10%

4-11 BATTERY LEVEL INDICATOR

A. Rotate the POWER switch to ON. A deflection of the BATTERY LEVEL indicator should be noted. If none is noted, but the ON pilot light is illuminated, the indicator circuit is probably faulty. Ascertain the battery voltage as it appears at 2TP3 is between +11V and +14V. If not, refer to Section 4-12 (Page 24) for battery charging information.

B. With the battery voltage output of between +11V and +14V, measure +11V at 2VR2's cathode. If not, check the continuity of 2R11, 2R12 and 1M1. If continuity checks show OK, replace 2VR2 and measure approximately +11V at 2VR2's cathode.

C. If the indicator, 1M1, is suspected, check full scale deflection by applying 1 milliamp DC to the indicator coil. Disconnect the wire at the indicator's plus (+) terminal before applying the current.

NOTE: The indicator has an expanded scale and will only begin to deflect when approximately +11V is applied to its (+) terminal.

4-12 BATTERY CHARGING CIRCUIT

To charge the internal Ni-Cad batteries, connect the AC Line Cord, as furnished, into its polarized POWER connector on the rear panel. Ascertain that the LINE VOLTAGE, as marked on the rear panel, agrees with the line voltage source to be used. Connect the cord's plug to the line voltage source. Rotate the POWER switch to BATTERY CHARGE. Note that the CHARGE pilot light is illuminated. An over-night charge will restore the batteries to their full operating capacity. If it becomes apparent the batteries are not taking the charge, refer to the following procedure for trouble-shooting the circuit.

A. Verify the LINE VOLTAGE slide switch, 4S1, is set to agree with the AC line voltage being used.

B. Verify the stated voltage and frequency are present at the AC line voltage source.

C. Check the FUSE, 4F1, for continuity. If faulty, replace with the same type and manufacture as factory installed.

D. Measure the AC voltages at the power transformer's primary and secondary; measure the DC voltage at the bridge rectifier, 2D1 and 2D2, output. Compare these measurements to those as shown on the Schematic Diagram.

E. Trace the DC charging voltage from the rectifier bridge to the batteries.

F. Measure the battery voltage as it appears at 2TP3. If the voltage is less than +10V, the batteries have fallen below their recommended discharge level. Place on a 24 hour charge and recheck the voltage output. If it measures a minimum of +13.5V, the batteries have recovered and can be used. However, should the initial battery voltage be less than +7V, the batteries are probably beyond repair. Contact Millivac for further instructions on how to proceed with battery replacement.

4-13 ADJUSTMENT OF BATTERY LEVEL INDICATOR

Adjustment of the BATTERY LEVEL indicator will probably become necessary when either the indicator meter, 1M1, or zener diode, 2VR2, is replaced. This adjustment is made while the Amplifier's cabinet is removed for the above component replacement.

A. With the POWER switch set to OFF, check and if necessary, adjust the meter's mechanical zero. To re-adjust, slowly rotate the mechanical zero screw (meter face) until the meter's pointer falls on the red line to the far left in the CHARGE range.

   NOTE: Due to the meter movement's mechanical characteristics, it may be necessary to gently tap the meter's face. This will assure accuracy in adjusting the mechanical zero.

B. Short the INPUT connector's signal carrying terminal to the connector's ground. Attach the DC digital voltmeter to 2TP1. Typical equipment set-up is shown in Fig. 4-3 (Page 25).

C. Rotate the POWER switch to ON. Adjust, if necessary, variable control, 2R8, until a reading of +12.00V is obtained.

D. On the power supply board, unsolder link, 2W1, from its connection to 2TP3.

E. Connect the auxilary DC power supply plus (+) terminal to 2TP3. Connect the minus (-) terminal to 2TP2. Set the DC power supply output to +15V.

F. Gradually reduce the auxilary DC power supply's output level until the voltage at 2TP1 drops from +12.00V to +11.99V(typical input regulation of internal P.S. is 0.1%). The output level from the auxilary DC power supply should be approximately +12.180V.

G. Rotate variable control, 2R12, (power supply board) until the BATTERY LEVEL meter's pointer falls on the red CHARGE line (between the CHARGE and OPERATE ranges).

NOTE: Due to the meter movement's mechanical characteristics, it may be necessary to gently tap the meter's face. This will assure accuracy in adjusting the BATTERY LEVEL indicator.

H. Increase the DC power supply's output level to approximately +14.00V. The meter's pointer should read to the far right in the OPERATE range.

I. The BATTERY LEVEL indicator is now adjusted. Detach the auxilary DC power supply, reconnect link, 2W1 to 2TP3.

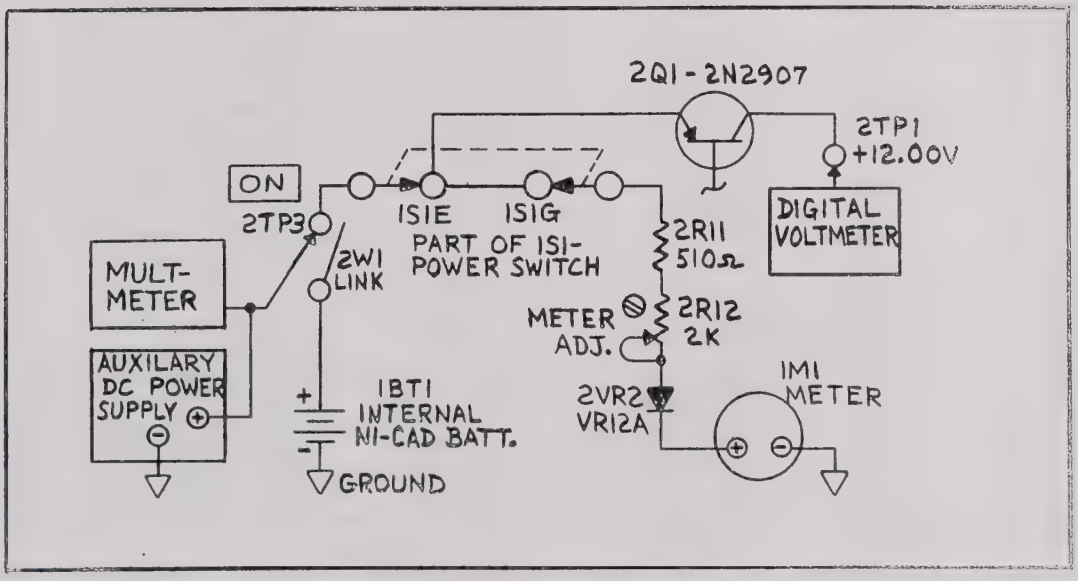


Fig. 4-3 Typical Equipment Set-up for Battery Level Indicator Adjustment

1-MA-164A-1001
1-MA-168A-1001

SECTION 5

REPLACEABLE PARTS LIST

5-1 REFERENCE DESIGNATION

	CLASS
A	Separable Assemblies
BT	Battery
C	Capacitor
D	Diode
DS	Lamp Assembly
F	Fuse
IC	Integrated Circuit
J	Connector
P	Plug
Q	Transistor
R	Resistor, Potentiometer
S	Switch
T	Transformer
TP	Test Point
VR	Zener/Voltage Regulator
W	Wire, Cable

5-2 PREFIX DESIGNATION

	LOCATION
1	Front Panel/Chassis/Switches
2	Power Supply Board
3	Main Amplifier Board
4	Power Plate
5	Filter Board

5-3 COMPONENTS

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
1A1	Test Lead	Furnished	900-3006	85711	UG-201
1A2	Test Lead	Accessory	900-3006	85711	UG-201
1A3	100:1 Resistive Divider	Optional Accessory	900-3030	85711	
1A4	1000:1 Resistive Divider	Furnished Accessory	900-3031	85711	
1A5	10,000:1 Resistive Divider	Optional Accessory	900-3032	85711	
1BT1	Battery Assy.	Chassis	460-1007	85711	
1C1	Cap. 10MF 50V NP	1S3	640-1026	74840	106BPA050N
1C2	Cap. 2MF 25V NP	1S3	640-1025	56289	TVAN-1202
1C3	Cap. .22MF 80V	1S3	630-1038	30039	YM-2200-1A
1C4	Cap. .02MF 200V	1S3	630-1031	54904	7F-203-2C
1C5	Cap. 2000pF	1S3	660-1006	81349	CM06FD202J03
1C6	Cap. 1000pF	1S3	660-1026	81349	CM06FD102J03
1C7	Cap. 510pF 500V	1S3	660-1005	81349	CM06FD511J03
1C8	Cap. .02MF 200V	1S4	630-1031	54904	7F-203-2C
1C9	Cap. .02MF 200V	1S4	630-1031	54904	7F-203-2C
1C10	Cap. .02MF 200V	1S4	630-1031	54904	7F-203-2C
1C11	Cap. .01MF 200V	1S4	621-1024	54904	3-103-2B
1C12	Cap. .0047MF 200V	1S4	621-1023	54904	3-472-2B
1C13	Cap. 2000pF	1S4	660-1006	81349	CM06FD202J03
1C14	Cap. 1000pF	1S4	660-1026	81349	CM06FD102J03
1C15	Cap. 510pF 500V	1S4	660-1005	81349	CM06FD511J03
1C16	Cap. 510pF 500V	1S4	660-1005	81349	CM06FD511J03
1C17	Cap. 200pF	1S4	660-1011	81349	CM05FD201J03
1C18	Cap. 68pF	1S4	660-1016	81349	CM05ED680J03
1C19	Cap. .22MF 100V (MA-168A)	1S5	621-1030	56289	2PSP22
1C20	Cap. .01MF 100V	Chassis	610-1008	59821	DC103
1C21	Cap. .01MF 100V	Chassis	610-1008	59821	DC103
1C22	Cap. 220MF 25V	1J2	640-1021	30039	TDA220M25
1C23	Cap. 68pF 1KV	1J2	610-1045	59821	DD680
1C24	Cap. 15pF 1KV	1S2	610-1032	59821	DD105
1DS1	Lamp, LED ON Pilot	Front Panel	110-3101	72619	559-0101-003
1DS2	Lamp, LED CHARGE Pilot	Front Panel	110-3101	72619	559-0101-003
1J1	Connector, INPUT	Front Panel	800-7000	81349	UG625B/U
1J2	Connector, OUTPUT	Front Panel	800-7000	81349	UG625B/U
1M1	Meter, Battery Level Indicator	Front Panel	204-1001	85711	

1-MA-164A-1001
1-MA-168A-1001

5-3 COMPONENTS (continued)

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
1MP1	Knob POWER Switch	1S1	800-4137	21604	PS70BL-L-2-BK
1MP2	Knob GAIN Switch	1S2	800-4137	21604	PS70BL-L-2-BK
1MP3	Knob LOWER B.P. Switch	1S3	800-4137	21604	PS70BL-L-2-BK
1MP4	Knob UPPER B.P. Switch	1S4	800-4137	21604	PS70BL-L-2-BK
1MP5	Knob I.P. IMP. Switch (MA-168A)	1S5	800-4137	21604	PS70BL-L-2-BK
1R1	Res. 4.7K ½W 5%	1S1	500-472	81349	RC20GF472J
1R2	Res. 100Ω ½W 5%	1S1	500-101	81349	RC20GF101J
1R3	Res. 191Ω ¼W 1%	1S2	512-1910	81349	RN60C1910F
1R4	Res. 412Ω ¼W 1%	1S2	512-4120	81349	RN60C4120F
1R5	Res. 280Ω ¼W 1%	1S2	512-2800	81349	RN60C2800F
1R6	Res. 412Ω ¼W 1%	1S2	512-4120	81349	RN60C4120F
1R7	Res. 280Ω ¼W 1%	1S2	512-2800	81349	RN60C2800F
1R8	Res. 412Ω ¼W 1%	1S2	512-4120	81349	RN60C4120F
1R9	Res. 280Ω ¼W 1%	1S2	512-2800	81349	RN60C2800F
1R10	Res. 412Ω ¼W 1%	1S2	512-4120	81349	RN60C4120F
1R11	Res. 280Ω ¼W 1%	1S2	512-2800	81349	RN60C2800F
1R12	Res. 412Ω ¼W 1%	1S2	512-4120	81349	RN60C4120F
1R13	Res. 110Ω ¼W 1%	1S2	512-1100	81349	RN60C1100F
1R14	Res. 56.2Ω ¼W 1% (MA-168A)	1S2	512-56R2	81349	RN60C56R2F
1R15	Res. 3.48K ¼W 1%	1S3	512-3481	81349	RN60C3481F
1R16	Res. 6.19K ¼W 1%	1S3	512-6191	81349	RN60C6191F
1R17	Res. 6.98K ¼W 1%	1S3	512-6981	81349	RN60C6981F
1R18	Res. 8.06K ¼W 1%	1S3	512-8061	81349	RN60C8061F
1R19	Res. 8.47K ¼W 1%	1S3	512-8471	81349	RN60C8471F
1R20	Res. 8.87K ¼W 1%	1S3	512-8871	81349	RN60C8871F
1R21	Res. 4.22K ¼W 1%	1S3	512-4221	81349	RN60C4221F
1R22	Res. 2.49K ¼W 1%	1S3	512-2491	81349	RN60C2491F
1R23	Res. 27.4K ¼W 1%	1S4	512-2742	81349	RN60C2742F
1R24	Res. 14K ¼W 1%	1S4	512-1402	81349	RN60C1402F
1R25	Res. 10.2K ¼W 1%	1S4	512-1022	81349	RN60C1022F
1R26	Res. 14K ¼W 1%	1S4	512-1402	81349	RN60C1402F
1R27	Res. 6.04 ¼W 1%	1S4	512-6041	81349	RN60C6041F
1R28	Res. 7.15K ¼W 1%	1S4	512-7151	81349	RN60C7151F
1R29	Res. 6.98K ¼W 1%	1S4	512-6981	81349	RN60C6981F
1R30	Res. 5.62K ¼W 1%	1S4	512-5621	81349	RN60C5621F
1R31	Res. 2.74K ¼W 1%	1S4	512-2741	81349	RN60C2741F
1R32	Res. 3.16K ¼W 1%	1S4	512-3161	81349	RN60C3161F
1R33	Res. 2.74K ¼W 1%	1S4	512-2741	81349	RN60C2741F
1R34	Res. 10K ¼W 1%	1J2	512-1002	81349	RN60C1002F

5-3 COMPONENTS (continued)

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
1S1	Switch, POWER	Front Panel	410-1143	85711	
	Switch Assy. Complete		420-1143	85711	
1S2	Switch, GAIN dB (MA-164A)	Front Panel	410-1144	85711	
	Switch Assy. Complete		420-1144	85711	
1S2	Switch, GAIN dB (MA-168A)	Front Panel	410-1145	85711	
	Switch Assy. Complete		420-1145	85711	
1S3	Switch, LOWER BANDPASS LIMIT	Front Panel	410-1146	85711	
	Switch Assy. Complete		420-1146	85711	
1S4	Switch, UPPER BANDPASS LIMIT	Front Panel	410-1147	85711	
	Switch Assy. Complete		420-1147	85711	
1S5	Switch, INPUT IMP. (MA-168A)	Front Panel	410-1148	85711	
	Switch Assy. Complete		420-1148	85711	
2A1	Power Supply Board Assy.	Chassis	450-1717	85711	
2C1	Cap. 1000MF 50V	2B2	640-1019	30039	TDA1000M50
2C2	Cap. 220MF 25V	2A2	640-1021	30039	TDA220M25
2C3	Cap. 100MF16V	2B1	635-1031	30039	PDA100M16
2C4	Cap. .1MF 50V	2B1	610-1039	56289	2CZ5U104X0050C4
2C5	Cap. 3.3MF 50V	2A1	632-1012	81349	CSR13G335KL
2C6	Cap. 3.3MF 50V	2B1	632-1012	81349	CSR13G335KL
2D1	Diode 1N4004	2B2	101-2024	14433	1N4004
2D2	Diode 1N4004	2B2	101-2024	14433	1N4004
2D3	Diode 1N4004	2B2	101-2024	14433	1N4004
2IC1	IC LM-358P	2A1	105-1002	01295	LM-358P
2Q1	Transistor PNP Sil	2A1	100-1027	07263	2N2907
2Q2	Transistor NPN Sil	2A1	100-1013	07263	2N2222

1-MA-164A-1001
1-MA-168A-1001

5-3 COMPONENTS (continued)

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
2R1	Res. 8.2K ½W 5%	2B2	500-822	81349	RC20GF822J
2R2	Res. 250Ω 5W	2B3	550-1005	44655	4602
2R3	Res. 3.9Ω ½W 5%	2A1	500-3R9	81349	RC20GF3R9J
2R4	Res. 69.8K ¼W 1%	2A1	512-6982	81349	RN60C6982F
2R5	Res. 10K ¼W 1%	2A1	512-1002	81349	RN60C1002F
2R6	Res. 4.75K ¼W 1%	2B1	512-4751	81349	RN60C4751F
2R7	Res. 27.4K ¼W 1%	2A1	512-2742	81349	RN60C2742F
2R8	Res. Var. 2K Pot	2A1	580-3055	11236	362U202B
2R9	Res. 10K ¼W 1%	2A1	512-1002	81349	RN60C1002F
2R10	Res. 10K ¼W 1%	2A1	512-1002	81349	RN60C1002F
2R11	Res. 510Ω ½W 5%	2B3	500-511	81349	RC20GF511J
2R12	Res. Var. 2K Pot	2A3	580-3055	11236	362U202B
2T1	Transformer, Power	2A2,2B2	300-1030	85711	
2VR1	Diode,Zener Selected	2B1	101-2047	85711	1N704
2VR2	Diode,Zener Selected	2B3	101-2048	85711	VR12A
2XIC1	Socket 8 pin DIP	2A1	800-7930	91506	308-AG37D
2XQ1	Socket TO18	2A1	800-7925	97913	MPT-4003-10
3A1	Amplifier, Board Assy (MA-164A)	Chassis	450-1718	85711	
3A2	Amplifier, Board Assy (MA-168A)	Chassis	450-1722	85711	
3C1	Cap. .02MF 600V (MA-168A)	3A1	610-1011	59821	DD203
3C2	Cap. 2MF 25V NP (MA-168A)	3A2	640-1025	56289	TVAN-1202
3C3	Cap. .12MF 100V (MA-168A)	3A1	621-1029	30039	EM-1200-1A
3C4	Cap. 2MF 25V NP (MA-168A)	3A2	640-1025	56289	TVAN-1202
3C5	Cap. 3.3MF 50V (MA-168A)	3A2	632-1012	81349	CS13BG335K
3C6	Cap. 470MF 16V (MA-168A)	3B1	635-1039	30039	TDA470M16
3C7	Cap. 470MF 16V	3A2	635-1039	30039	TDA470M16
3C8	Cap. .02MF 600V	3A2	610-1011	59821	DD203
3C9	Cap. 220MF 25V	3A3	640-1021	30039	TDA220M25

1-MA-164A-1001
1-MA-168A-1001

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
3C10	Cap. .02MF 600V	3B2	610-1011	59821	DD203
3C11	Cap. 220MF 25V	3B2	640-1021	30039	TDA220M25
3C12	Cap. .02MF 600V	3A3	610-1011	59821	DD203
3C13	Cap. 3.3MF 50V	3A3	632-1012	81349	CS13BG335K
3C14	Cap. 5pF 1KV	3A3	610-1044	59821	DD050
3C15	Cap. .02MF 600V	3A4	610-1011	59821	DD203
3C16	Cap. 3.3MF 50V	3A4	632-1012	81349	CS13BG335K
3C17	Cap. 470MF 16V	3B3	635-1039	30039	TDA470M16
3C18	Cap. .02MF 600V	3B3	610-1011	59821	DD203
3C19	Cap. .02MF 600V	3A4	610-1011	59821	DD203
3C20	Cap. 3.3MF 50V	3A4	632-1012	81349	CS13BG335K
3C21	Cap. 470MF 16V	3B4	635-1039	30039	TDA470M16
3C22	Cap. 5pF 1KV	3B4	610-1044	59821	DD050
3C23	Cap. .002MF 1KV	3B4	610-1006	71590	DD202
3D1	Diode,Selected (MA-168A)	3A1	101-2026	85711	1N914
3D2	Diode,Selected (MA-168A)	3A1	101-1026	85711	1N914
3Q1	Transistor FET Selected (MA-168A)	3A1	100-1029	85711	FN3620
3Q2	Transistor NPN SIL (MA-168A)	3A2	100-1033	04713	MPSA18
3Q3	Transistor Selected	3A3	100-1037	85711	2N5179
3Q4	Transistor NPN SIL	3A3	100-1013	27014	2N2222
3Q5	Transistor NPN SIL	3A3	100-1013	27014	2N2222
3Q6	Transistor Selected	3A3	100-1013	85711	2N2222
3Q7	Transistor NPN SIL	3A4	100-1013	27014	2N2222
3R1	Res. 300Ω ½W 5% (MA-168A)	3A1	500-300	81349	RC20GF300J
3R2	Res. 10M ¼W 1% (MA-168A)	3A1	513-1005	33224	HVA65-1005F
3R3	Res. 2.25M ¼W 1% (MA-168A)	3A1	513-2254	33224	HA60-2254F
3R4	Res. 27M ½W 1% (MA-168A)	3A1	513-2705	33224	HA60-2705F
3R5	Res. 1M ¼W 1% (MA-168A)	3A1	512-1004	81349	RN60C1004F
3R6	Res. 10K ¼W 1% (MA-168A)	3A1	512-1002	81349	RN60C1002F
3R7	Res. 10K ¼W 1% (MA-168A)	3B1	512-1002	81349	RN60C1002F

1-MA-164A-1001
1-MA-168A-1001

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
3R8	Res. 33.2Ω ¼W 1% (MA-168A)	3A1	512-33R2	81349	RN60C33R2F
3R9	Res. 2.2K ½W 5% (MA-168A)	3A1	500-222	81349	RC20GF222J
3R10	Res. 825Ω ¼W 1% (MA-168A)	3B2	512-8250	81349	RN60C8250F
3R11	Res. 20K ¼W 1%	3B2	512-2002	81349	RN60C2002F
3R12	Res. 20K ¼W 1%	3B3	512-2002	81349	RN60C2002F
3R13	Res. 33.2Ω ¼W 1%	3A3	512-33R2	81349	RN60C33R2F
3R14	Res. 3.32K ¼W 1%	3A2	512-3321	81349	RN60C3321F
3R15	Res. 10Ω ¼W 1%	3B3	512-10R0	81349	RN60C10R0F
3R16	Res. 33.2Ω ¼W 1%	3A3	512-33R2	81349	RN60C33R2F
3R17	Res. 100Ω ¼W 1%	3B3	512-1000	81349	RN60C1000F
3R18	Res. 33.2Ω ¼W 1%	3A3	512-33R2	81349	RN60C33R2F
3R19	Res. 3.32K ¼W 1%	3A3	512-3321	81349	RN60C3321F
3R20	Res. 33.2Ω ¼W 1%	3A3	512-33R2	81349	RN60C33R2F
3R21	Res. 402K ½W 1%	3A3	512-4023	81349	RN60C4023F
3R22	Res. 133K ¼W 1%	3B4	512-1333	81349	RN60C1333F
3R23	Res. 33.2Ω ¼W 1%	3A3	512-33R2	81349	RN60C33R2F
3R24	Res. 2K ¼W 1%	3A3	512-2001	81349	RN60C2001F
3R25	Res. 374Ω ¼W 1%	3B3	512-3740	81349	RN60C3740F
3R26	Res. 33.2Ω ¼W 1%	3A4	512-33R2	81349	RN60C33R2F
3R27	Res. 33.2Ω ¼W 1%	3A4	512-33R2	81349	RN60C33R2F
3R28	Res. 1K ¼W 1%	3B4	512-1001	81349	RN60C1001F
3R29	Res. Var. 2K Pot	3B4	580-3055	11236	362U202B
3R30	Res. 12.1K ¼W 1% (MA-164A)	3B4	512-1221	81349	RN60C1221F
3R30	Res. 13.3K ¼W 1% (MA-168A)	3B4	512-1332	81349	RN60C1332F
3R31	Res. Selected	3B4			
3R32	Res. 604Ω ¼W 1% (MA-168A)	3B1	512-6040	81349	RN60C6040F
3R33	Res. 49.9Ω ¼W 1%	3B4	512-49R9	81349	RN60C49R9F
3VR1	Diode, Zener Selected(MA-168A)	3A1	101-2029	85711	1N758
3VR2	Diode, Zener Selected(MA-168A)	3A1	101-2029	85711	1N758
3XQ1	Socket TO72 (MA-168A)	3A1	800-7918	97913	MPT-4004-4
3XQ2	Socket TO18 (MA-168A)	3A1	800-7925	97913	MPT-4003-10
3XQ3	Socket TO72	3A3	800-7918	97913	MPT-4004-4
3XQ4	Socket TO18	3A3	800-7925	97913	MPT-4003-10

5-3 COMPONENTS (continued)

Ref. Des.	Description	Location	Millivac Part No.	FSCM	Manufacturer's Part No.
4A1	Power Panel Assy (MA-164A)	Chassis	450-1719	85711	
4A1	Power Panel Assy (MA-168A)	Chassis	450-1723	85711	
4C1	Cap. .01MF 1.4KV	4J1	610-1017	56289	125L-S10
4C1	Cap. .01MF 1.4KV	4J1	610-1017	56289	125L-S10
4F1	Fuse 3AG .3A Slo-Blo	4XF1	800-1006	75915	313.300
4J1	Recepticle, Power Cord	4A1	800-7421	70903	17252
4P1	Power Cord Assy.	4J1	800-5122	70903	17251
4S1	Switch, Slide 115V/230V	4A1	400-1015	82389	46256LFE
4XF1	Fuse Post 3AG	4A1	800-2105	75915	342004
5A1	Filter Board Assy. (MA-164A)	Chassis	450-1720	85711	
5A1	Filter Board Assy. (MA-168A)	Chassis	450-1724	85711	
5C1	Cap. 100MF 16V	5A1	635-1006	30039	TDA100M16
5C2	Cap. .02MF 600V	5A1	610-1011	59821	DD203
5C3	Cap. 100MF 16V	5A1	635-1006	30039	TDA100M16
5C4	Cap. 10MF 50V NP	5A1	640-1026	74840	106BPA050N
5C5	Cap. .02MF 600V	5A1	610-1011	59821	DD203
5C6	Cap. 100MF 16V	5A1	635-1006	30039	TDA100M16
5Q1	Transistor NPN SIL	5A1	100-1013	27014	2N2222
5Q2	Transistor NPN SIL	5A1	100-1013	27014	2N2222
5R1	Res. 402K ¼W 1%	5A1	512-4023	81349	RN60C4023F
5R2	Res. 49.9Ω ¼W 1%	5A1	512-49R9	81349	RN60C49R9F
5R3	Res. 2K ¼W 1%	5A1	512-2001	81349	RN60C2001F
5R4	Res. 15Ω ¼W 1%	5A1	512-15R0	81349	RN60C15R0F
5R5	Res. 402K ¼W 1%	5A1	512-4023	81349	RN60C4023F
5R6	Res. 49.9Ω ¼W 1%	5A1	512-49R9	81349	RN60C49R9F
5R7	Res. 1K ¼W 1%	5A1	512-1001	81349	RN60C1001F
5R8	Res. 100Ω ¼W 1%	5A1	512-1000	81349	RN60C1000F
5XQ1	Socket TO18	5A1	800-7925	97913	MPT-4003-10
5XQ2	Socket TO72	5A1	800-7918	97913	MPT-4004-4

1-MA-164A-1001
1-MA-168A-1001

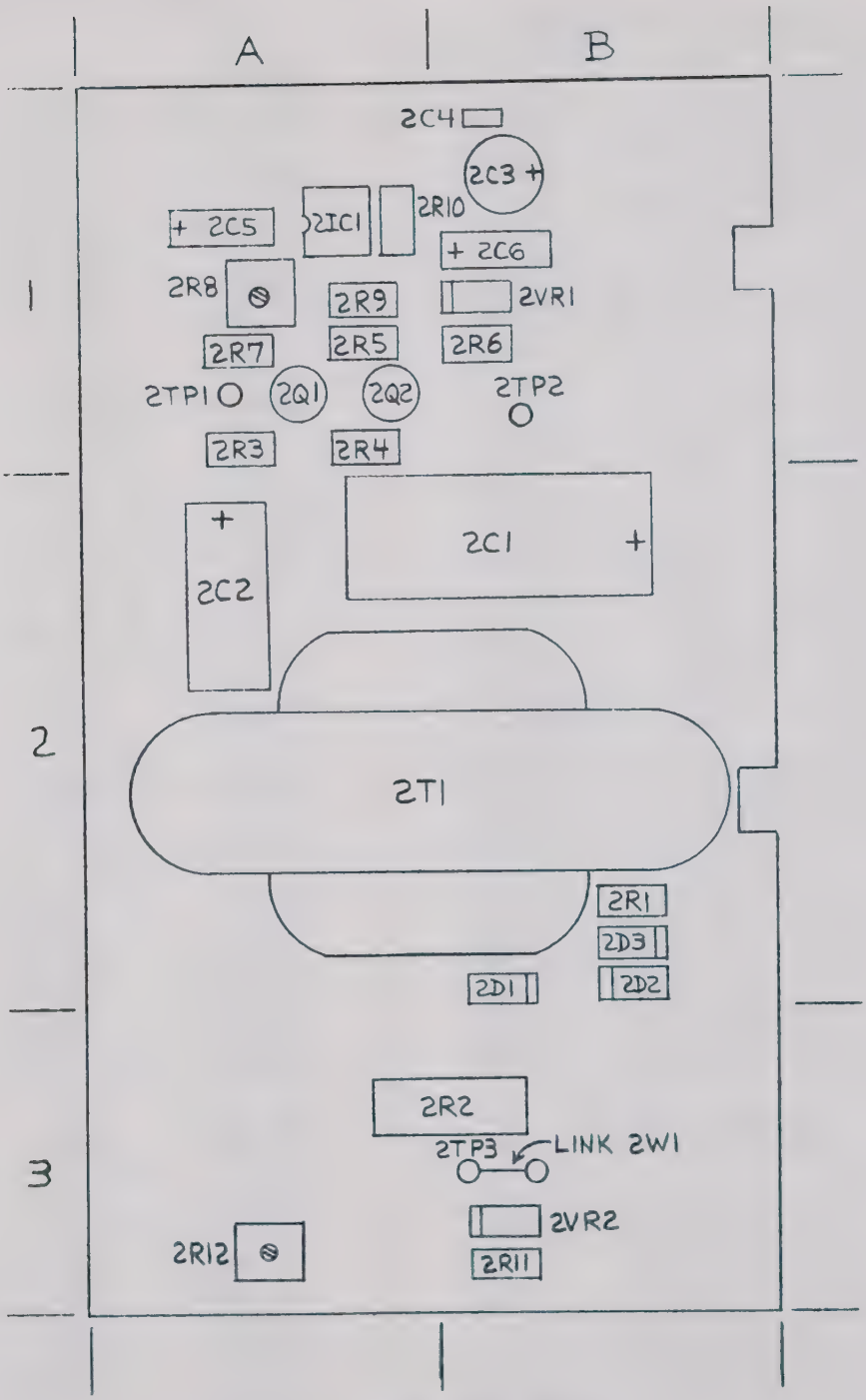


FIG. 5-1 COMPONENT LAYOUT - POWER SUPPLY BOARD

1-MA-164A-1001
1-MA-168A-1001

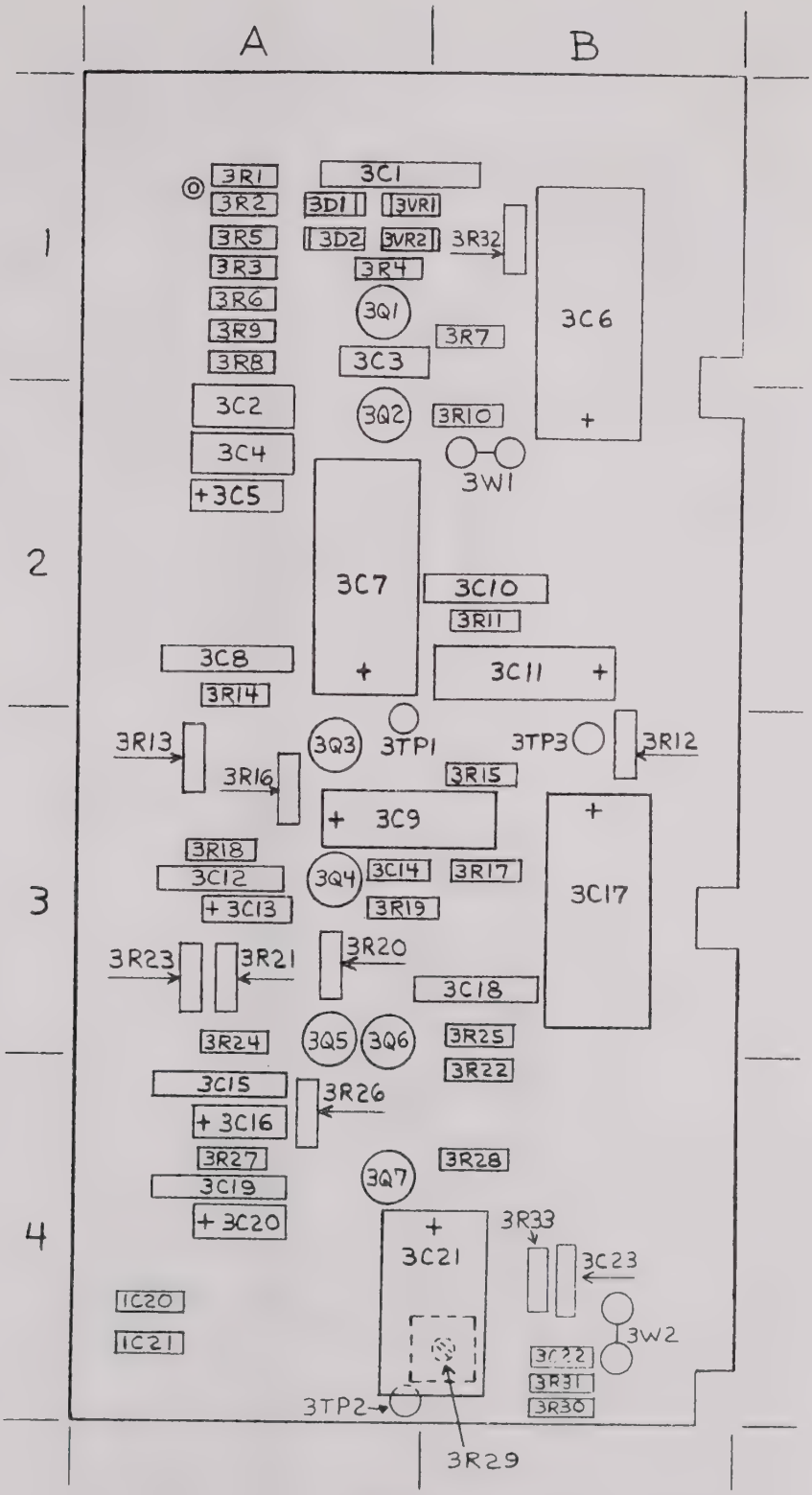


FIG. 5-2 COMPONENT LAYOUT - AMPLIFIER BOARD

1-MA-164A-1001
1-MA-168A-1001

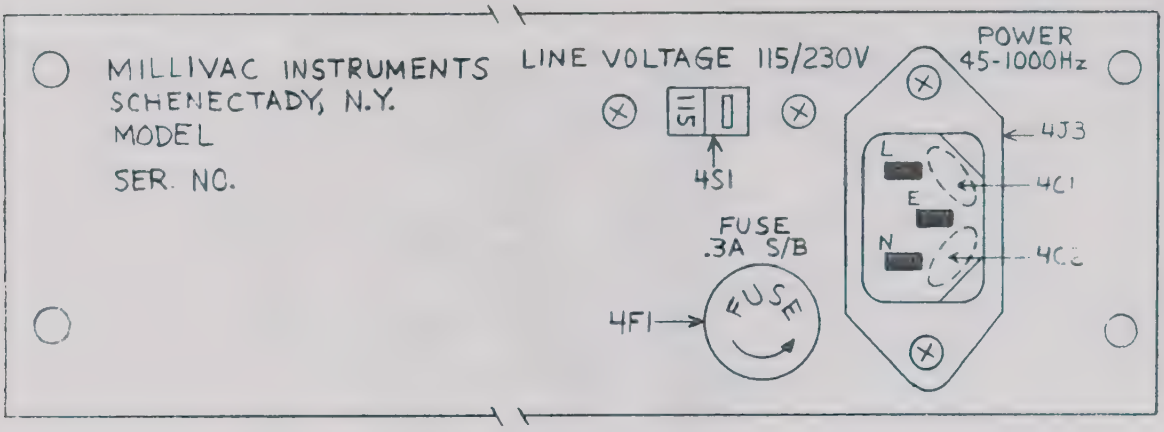


FIG. 5-3 COMPONENT LAYOUT - POWER PANEL

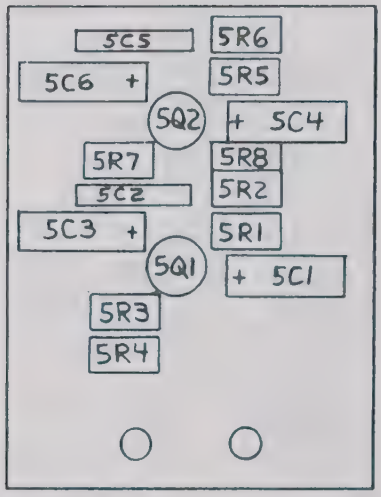
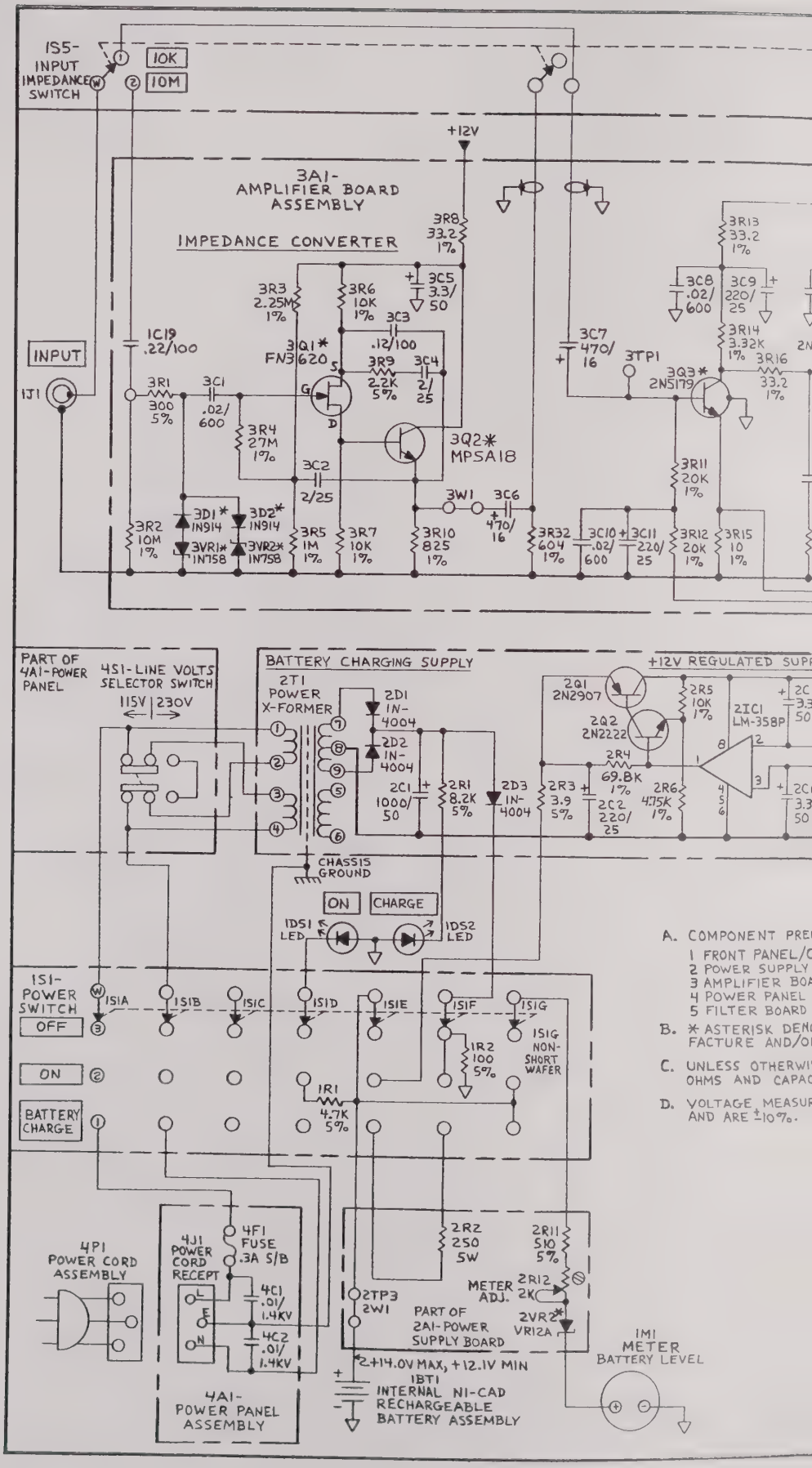
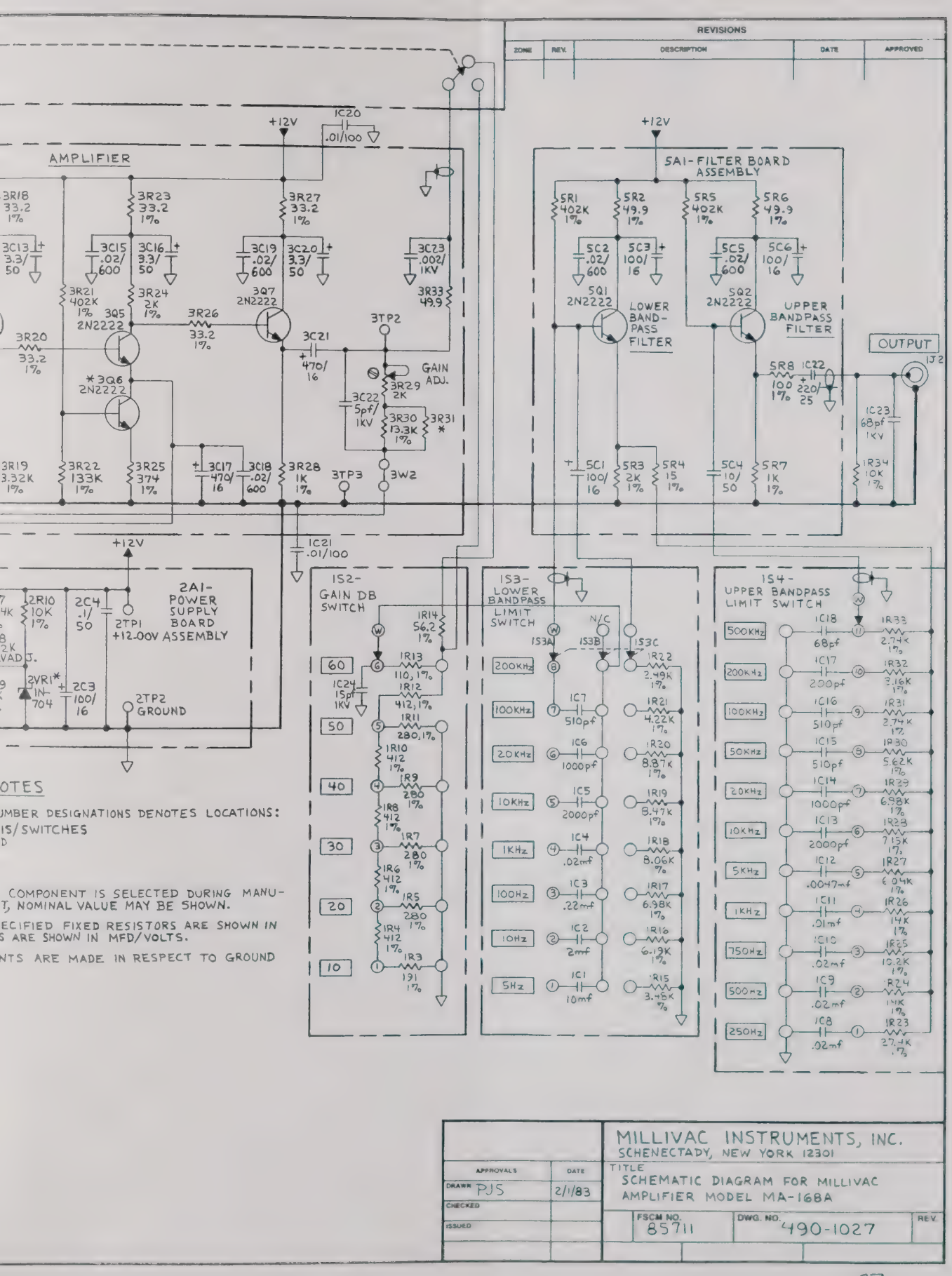


FIG. 5-4 COMPONENT LAYOUT - FILTER BOARD


1S5- INPUT IMPEDANCE SWITCH
10K
10M
+12V
3A1- AMPLIFIER BOARD ASSEMBLY
IMPEDANCE CONVERTER
INPUT
1J1
1C19 .22/100
3R1 300 5%
3C1 .02/ 600
3R2 10M 1%
3R3 2.25M 1%
3R4 27M 1%
3R5 1M 1%
3R6 10K 1%
3C2 2/25
3C3 .12/100
3C4 2/ 25
3C5 3.3/ 50
3R7 10K 1%
3R8 33.2 1%
3Q1* FN3620
3R9 2.2K 5%
3Q2* MPSA18
3D1* IN914
3D2* IN914
3VR1* IN758
3VR2* IN758
3W1
3C6 470/ 16
3R10 825 1%
3R32 604 1%
3C7 470/ 16
3TP1
3C8 .02/ 600
3C9 220/ 25
3R13 33.2 1%
3R14 3.32K 1%
3R16 33.2 1%
3Q3* 2N5179
3R11 20K 1%
3C10 .02/ 600
3C11 220/ 25
3R12 20K 1%
3R15 10 1%
PART OF 4A1-POWER PANEL
4S1-LINE VOLTS SELECTOR SWITCH
115V 230V
BATTERY CHARGING SUPPLY
2T1 POWER X-FORMER
2D1 IN-4004
2D2 IN-4004
2D3 IN-4004
2C1 1000/ 50
2R1 8.2K 5%
CHASSIS GROUND
+12V REGULATED SUPP
2Q1 2N2907
2Q2 2N2222
2R4 69.8K 1%
2R5 10K 1%
2R3 3.9 5%
2C2 220/ 25
2R6 4.75K 1%
2IC1 LM-358P
ON
CHARGE
1DS1 LED
1DS2 LED
1S1- POWER SWITCH
OFF
ON
BATTERY CHARGE
1S1A
1S1B
1S1C
1S1D
1S1E
1S1F
1S1G
1S1G NON-SHORT WAFER
1R2 100 5%
1R1 4.7K 5%
4P1 POWER CORD ASSEMBLY
4J1 POWER CORD RECEPT
4F1 FUSE .3A S/B
4C1 .01/ 1.4KV
4C2 .01/ 1.4KV
4A1- POWER PANEL ASSEMBLY
2R2 250 5W
2R11 510 5%
2R12 2K
METER ADJ.
2TP3
2W1
PART OF 2A1-POWER SUPPLY BOARD
2VR2* VR12A
+14.0V MAX, +12.1V MIN
1BT1 INTERNAL NI-CAD RECHARGEABLE BATTERY ASSEMBLY
1M1 METER BATTERY LEVEL
A. COMPONENT PRE
1 FRONT PANEL/C
2 POWER SUPPLY
3 AMPLIFIER BOA
4 POWER PANEL
5 FILTER BOARD
B. * ASTERISK DEN
FACTURE AND/O
C. UNLESS OTHERWI
OHMS AND CAPAC
D. VOLTAGE MEASUR
AND ARE ±10%.



OTES

UMBER DESIGNATIONS DENOTES LOCATIONS:
IS/SWITCHES
D

COMPONENT IS SELECTED DURING MANU-
T, NOMINAL VALUE MAY BE SHOWN.

ECIFIED FIXED RESISTORS ARE SHOWN IN
S ARE SHOWN IN MFD/VOLTS.

NTS ARE MADE IN RESPECT TO GROUND

APPROVALS	DATE
DRAWN PJS	2/1/83
CHECKED	
ISSUED	

MILLIVAC INSTRUMENTS, INC.
SCHENECTADY, NEW YORK 12301

TITLE
SCHEMATIC DIAGRAM FOR MILLIVAC
AMPLIFIER MODEL MA-168A

FSCM NO.	DWG. NO.	REV.
85711	490-1027	

FSCM	Manufacturer	
K0099	Jackson Brothers	London, England
1G939	Magnacraft	Northbrook, IL
9T572	Hy-Meg Corp.	Addison, IL
00779	Amp, Inc.	Harrisburg, PA
01295	Texas Instruments	Dallas, TX
02660	Amphenol	Broadview, IL
02735	RCA Corp., Solid State Div.	Somerville, NJ
03911	Clairex Corp.	Mt. Vernon, NY
04713	Motorola Inc., Semiconductor Div.	Phoenix, AZ
06555	Beede Electrical Instruments	Penacook, NH
07263	Fairchild Semiconductor	Mountain View, CA
09214	GE Semiconductor	Auburn, NY
11236	CTS of Berne, Inc.	Berne, IN
12136	PHC Industries	Camden, NJ
12673	Wesco Electrical Co. Inc.	Greenfield, MA
14433	ITT SemiConductors	West Palm Beach, FL
15915	Tepro of Florida, Inc.	Clearwater, FL
16237	Connector Corp.	Chicago, IL
17856	Siliconix Inc.	Santa Clara, CA
21604	Buckeye Stamping Co.	Columbus, OH
27014	National Semiconductor	Santa Clara, CA
28520	Heyco Molded Products	Kenilworth, NJ
30039	See 61499	
32293	Intersil Inc.	Cupertino, CA
32997	Bourns Inc.	Riverside, CA
36346	Union Carbide/Eveready	Danbury, CT
44655	Ohmite Mfg. Co.	Skokie, IL
50434	Hewlett-Packard, Opto Div.	San Jose, CA
50930	Acushnet Capacitor Co., Inc.	New Bedford, MA
51406	Murata/Erie	Marietta, GA
53184	Xciton Corp.	Latham, NY
54904	Eltra Corp., Medwec Div.	Scottsbluff, NE
55578	CTS of West Liberty	West Liberty, OH
56289	Sprague Electric Co.	Hudson, NH
58361	General Instruments, Opto Div.	Palo Alto, CA
59660	Tusonix	Tucson, AZ
59821	Medco/Centralab, Div. N.A. Philips	El Paso, TX
61499	International Comp. Corp.	Melville, NY
61529	Aromat Corp.	New Providence, NJ
70485	Atlantic India Rubber Co.	Chicago, IL
70903	Belden Corp.	Geneva, IL
71450	CTS Corp.	Elkhart, IL
71590	Medco/Centralab, Switch Div.	Fort Dodge, IA
71744	General Instruments, Lamp Div.	Chicago, IL
72619	Dialight Corp.	Brooklyn, NY
74025	Marathon Battery Co.	Waco, TX
74840	Illinois Capacitor Co.	Lincolnwood, IL
75042	TRW Electronic Components	Philadelphia, PA
75915	Tracor Littlefuse Inc.	Des Plaines, IL
77764	Resistance Products	Harrisburg, PA
78277	See 1G939	
80089	United Tech/Stancor	Logansport, IN
81349	Military Spec.	
82389	Switchcraft Inc.	Chicago, IL
83330	Kulka Smith Inc.	Hanasquan, NJ
84171	Arco Electronics Inc.	Commack, NY
85711	Millivac Instruments, Inc.	Schenectady, NY
91506	Augat Inc.	Attleboro, MA
91833	Keystone Electronics	New York, NY
95263	Leecraft Mfg. Co., Inc.	Long Island City, NY
96906	Military Standards	
97913	Industrial Electronics Hdw. Corp.	New York, NY

GUARANTEE

Millivac Instruments, Inc. guarantees each instrument manufactured by us to be free from defects in material and workmanship for a period of one year from date of delivery to the original purchaser. Repairs during this time will be made by us free of charge, but transportation charges both ways will be borne by the customer.

Excluded from this guarantee are tube and transistor replacements, as well as all damages caused by, or related to, abuse of the instrument either electrically or mechanically. In this case, repairs will be billed at cost and an estimate will be submitted for your approval before the work is started.

If an instrument is believed to be defective, please notify our Service Department, giving the model number and serial number of the instrument, as well as describing the nature of the trouble. Our Service Department will then, if necessary, authorize the return of the instrument under the terms of this guarantee and advise how shipment should be made.

CLAIM FOR DAMAGE IN SHIPMENT

If, on receipt, the shipping cartons appear to be crushed or torn, as evidencing rough treatment, a notation should be made on the carrier's delivery receipt indicating this condition.

As each item is opened, it should be inspected to ascertain that no damage has been incurred during shipment. If no damage is visible, operational checks should be performed to make sure that the equipment arrives in its original operating condition. If any damage is revealed, a claim should be filed immediately with the carrier, stating the extent of the damage. A copy of this report should be forwarded to us along with the model and serial number of the instrument. Millivac will then advise how the instrument should be returned for repair or replacement.

SHIPPING INSTRUCTIONS FOR RETURNS TO FACTORY

No instrument should be returned to the factory without prior authorization from Millivac Instruments, Inc. or our authorized representative.

Shipping instructions will be given at the time return of an instrument is authorized. In all cases the instrument should be packed in a strong container and surrounded by sufficient shock-absorbing material.

MP MASTER
MA34744